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VOLUMINOUS SUCROSE CONSUMPTION IN FEMALE RATS: INCREASED "NIPPINESS" DURING PERIODS OF SUCROSE REMOVAL AND POSSIBLE OESTRUS PERIODICITY[1]

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Summary.—In a two-bottle paradigm in which water and 10% sucrose water were always available, female rats drank about 200 cc of the sugar water (about 65 g of sucrose/kg) per day for 4 wk. There were no significant decreases in consumption over this time. In Exp. 2 female rats singly housed were given two bottles containing water for 1 wk. and then a bottle containing water and a bottle containing 15% sucrose for the next week for 6 wk. When sucrose was available, the rats ate 33% more rat chow. When sucrose was removed, the rats displayed more episodes of biting a stimulus when the food cubes were being removed for daily measurements. Some females exhibited a marked 4- to 5-day periodicity in sucrose (7.5%) consumption. The persistent and voluminous consumption of sucrose water and enhanced agonistic-like behavior during periods of withdrawal suggests the presence of a robust phenomenon with potential clinical applications to the challenge of addiction.

During experiments with options of multiple fluids (1% saline, 10% sucrose, water, or quinine water) to discern changes in gustatory ratios during pregnancy (1), the second author observed that normal 6-mo.-old rats consumed the sucrose water but not the other fluids. The rats drank between 150 cc and 200 cc of 10% sucrose but less than 2 cc of water per day. This amount was comparable to about 60% of their body weight for the daily consumption of fluid and about 10% of their body weight in the consumption of sugar.

To discern the characteristics of this selective, voluminous consumption of sucrose solutions, four female Wistar rats about 6 mo. of age (about 300 g) were housed singly. Two bottles, one containing tap water and the other containing 10% sucrose, were available *ad libitum* for 28 days for each rat. Sucrose water and water were measured daily and replaced with fresh solutions. The mean and standard deviation for the consumption of sucrose fluid consumption per day were 193 cc and 25 cc; for the water these values were 0.8 cc and 1.2 cc.

To discern if there were any changes over the 4-wk. period correlations were completed between days and water and sucrose consumption for each rat. There were no statistically significant changes (all *r*s between −.10 and .21) over time. To control for possible leakage, although unlikely, bottles containing sucrose and water were attached to empty cages on the same rack containing the rats to accommodate for possible vibrations from animals movements or changing of the pan below each cage. Over 1 wk. the loss for either the water bottle or the sucrose bottle was no more than 2 to 4 cc.

In Exp. 2, four female Wistar rats 9 mo. of age were exposed to the same two-bottle paradigm. In this instance 15% sucrose water was available in one bottle while water was available in the other for each rat. The rats were given the option of the sucrose solution or water for 1 wk. followed by two bottles that contained only water (no sucrose) for 1 wk. This was repeated three times.

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Daily food consumption was also measured. After the removal of sucrose during the second week, conspicuous "aggressiveness" of the rats was observed. Consequently, the numbers of times each female rat nipped the experimenter's pen (used as a distractor to obtain the food cubes for weighing) or the experimenter's hand were counted. They were labelled as nips rather than bites because, although they could penetrate the skin, they did not display the characteristics of male aggression. It was associated with protrusion of the eyes, a distinct expression of the face, and a marked perseveration of biting or tenacity of a single bite. For the analyses the median values for fluid and food consumptions each week were utilized; the sum of the numbers of nips per week were analyzed.

Two-way analyses of variance, with both levels repeated (sucrose present vs sucrose absent and Blocks 1, 2, vs 3) showed that the rats drank significantly ($F_{1,3}=540.37$, $p<.001$; $\eta^2=99\%$ of the variance) more water when the sucrose was absent than when it was present. The *M*s for the two conditions were 33.5 (*SD*: 3.1 cc) and 0.5 (*SD*: .4 cc). The rats consumed significantly more food during the weeks they received sucrose water ($F_{1,3}=43.55$, $p<.001$; $\eta^2=95\%$) than during the weeks they did not. The *M*s were 19.1 (*SD*: 1.2 g) and 14.0 (*SD*: 1.4 g), respectively. The females also displayed ($F_{1,3}=18.69$, $p<.05$; $\eta^2=86\%$ of variance) more nips ($M=2.4$, $SD=1.9$) during the weeks the sucrose was not present (two bottles of tap water instead) than the weeks when the bottle of sucrose water and tap water were present ($M=.9$, $SD=.6$). The *M* and *SD* for the amount of the 15% sucrose fluid consumed for the three blocks were 132 cc and 11 cc, respectively.

There were no statistically significant differences between the blocks for the numbers of nips or the amounts of fluid or food consumption. The interaction between block and presence/absence of sucrose was significant ($F_{2,6}=19.29$, $p<.01$) for the food consumption and was not significant for number of nips ($F_{2,6}=3.24$, $.10>p>.05$). *Post hoc* analysis indicated this interaction for food was due to the relative reduction in food consumption across blocks during sucrose weeks while there was no significant change across blocks for the weeks during which only water was available. During the weeks with only water the means ranged between 13.5 g and 14.7 g while the *SD*s ranged between .8 and 1.7 g.

However, during the three alternating weeks with sucrose the means were 21.0 g (*SD*: 2.1), 18.5 g (*SD*: 1.7), and 17.7 g (*SD*: 0.9), respectively. The interaction between block and condition for numbers of nips per week reflected the more frequent nips during the last block of sucrose (*M*: 2.0, *SD*: 1.4) than during the previous two blocks (*M*: .2, *SD*: .5 and *M*: .5, *SD*: 1.0, respectively), while the mean numbers of nips during the periods with no sucrose did not differ significantly from each other.

In Exp. 3 (first author), that followed the procedures of Exps. 1 and 2, four 7-mo.-old female rats had access to a bottle of water and a bottle of 7.5% sucrose *ad libitum* for 45 days. The daily consumptions of sucrose fluid (in cc) per day are shown in Fig. 1. A 4- to 5-day cycle was evident for two of the rats (dark circles) but not for the other two (dotted lines). Spectral analysis (Plotter; Shareware) verified the presence of a significant elevation in power for a 4-day (closed circle) and 5-day (closed diamond) periodicity. These periodicities were not observed for the daily consumptions of water.

The voracious nature of the sucrose consumption was evident daily when the bottles containing the water and the sucrose were removed, refreshed, and returned. The rats would approach the sucrose bottle and lick for several minutes even though the bottle had been removed for only a few minutes. The behavior of the females during periods of sudden removal of the sucrose after 1 wk. of availability *ad libitum* was qualitatively different from male aggression and was similar to the nippiness observed in rats receiving postnatal treatments that simulate depression (2).

The apparent deviation from homeostasis with respect to the volume of sugar water consumed and the enhanced agonistic behavior during periods of withdrawal from the option to

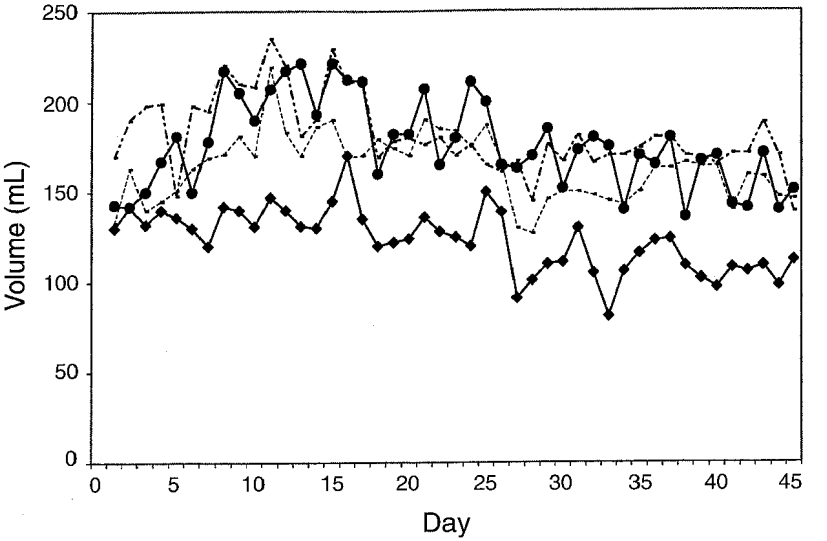

FIG. 1. Amount of 7.5% sucrose water consumed daily (despite an option to consume only water) over 45 continuous days for four female rats. The filled symbols indicate rats that exhibited the significant 4- or 5-day periodicity.

drink such copious volumes suggest a powerful central mechanism involved with this interesting dimer of glucose and fructose. The occurrence of a periodic consumption of sucrose water that is similar to the rat's oestrus cycle, although not obvious in all females, suggests that quantitative changes in the preference for or palatability of sucrose may be associated with the reproductive cycle.

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